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THE BIOLOGY OF THE ALDER FLEA-BEETLE

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BULLETIN 265

THE BIOLOGY OF THE ALDER FLEA-BEETLE, *Altica bimarginata* Say.[1]

WILLIAM COLCORD WOODS[2]

OCCURRENCE AND DISTRIBUTION.

Almost one hundred years have passed since Thomas Say (1842) first described the alder flea-beetle, *Altica bimarginata* Say,[3] but although periodically this insect appears in enormous numbers, no detailed work on its life history has yet been published, despite its wide distribution.

In the United States this beetle occurs from Maine to California, and it has also been reported from Canada. The following list includes all of the published distributional records which the writer has found: Maine (Packard 1890, Johannsen 1912); New Hampshire (Harris 1869, Packard 1890); New York (Linter 1887, Felt 1905, Britton 1911); Minnesota (Lugger 1899); Iowa (Sturm 1843); Missouri (Say 1824); Nebraska (Bruner 1893); Kansas (Le Conte 1859, 1860); New Mexico (Le Conte 1859); Oregon (Le Conte 1860); California (Mannerheim 1843, Le Conte 1857, 1860, Essig 1915); Mackenzie River Region, Canada (Le Conte 1860, Gibson 1913); British Columbia, Canada (Gibson 1913); Alberta, Canada (Gibson 1913); Nova Scotia, Canada (Gibson 1913).

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[1]Papers from the Maine Agricultural Experiment Station: Entomology No. 93.

Contribution from the Entomological Laboratory of Cornell University.

[2]Member of the Station Summer Staff.

[3]*Altica bimarginata* Say. Jour. Acad. Nat. Sci. Phila. 1824. V. 4, p. 85.
alni Harris. Ent. cor. ed. Scudder, 1869, p. 267.
ambiens Le Conte. Col. Kans. 1859, p. 25.
carinata Sturm. Cat. 1843, p. 282.
plicipennis Mannerheim. Bul. de Moscou, 1843, p. 310.
prasina Le Conte. Rept. Pac. R. R. Survey. 1857, p. 67.
subplicata Le Conte. Col. Kans. 1859. p. 25.

Altica[1] is the type genus of Alticini, one of the tribes into which the family Chrysomelidae, the leaf-beetles, is commonly divided. The members of this tribe are popularly known as flea-beetles because of their extraordinary powers of leaping, due to the strong muscles enclosed in the greatly enlarged femora of their hind legs. While Geoffroy (1762) stated that these insects could "jump with the agility of fleas", the first writer who actually referred to them as flea-beetles, seems to have been DeGeer (1775) who wrote "In Sweden they are known under the name Lopp-mask, that is to say, flea-beetle."

Among the European species of *Altica,* the injurious turnip-fly, *A. nemorum* Fab., is the best known, and of our American forms the destructive grape-vine flea-beetle, *A. chalybea* Ill., is a familiar example. Besides *A. chalybea,* at least two other species of *Altica* in addition to *bimarginata* Say occur in this state, the biology of which will be discussed in a forthcoming bulletin of this Experiment Station.

Although the alder flea-beetle is usually rather scarce, it may occur more or less periodically in enormous numbers, as has been intimated above. The first recorded outbreak was noted by Harris (1869) while he was traveling in New Hampshire, near Conway. Lintner (1888) gave an interesting account of the depredations caused by this species near Elizabethtown, N. Y., in 1877, and around Lake Pleasant, N. Y., in 1887. Packard (1890) mentioned this species as very abundant in Maine and New Hampshire in 1886 and 1887.

Similar outbreaks occurred in the State of Maine during the years from 1912 to 1915, and the observations recorded in this paper were made during those summers. The first specimens which were referred to the Experiment Station were sent in from Pan's Hill, Maine, in mid-July 1912. Later in the season, the beetles and their larvae were found working extensively on the alders in the Bangor Bog, near Orono. In 1913 they were extremely abundant all through the township of Orono and in many other parts of the state. The writer observed them in the townships immediately east of Orono, as far north as Mattawamkeag, and as far west as Oakland. They were not

[1]A discussion of the synonymy of the genus *Altica* Geoffroy, with the reasons for changing the name from *Haltica,* will be found on page

found in Lewiston, nor in Hancock and Washington Counties. Mr. John D. Tothill informed me that the beetles were present and abundant in New Brunswick, and Dr. Robert Matheson, in Nova Scotia.

So far as Maine is concerned, the year of maximum abundance was 1914. Even in the single township of Orono, the individuals of this species must have numbered many millions. The leaves were riddled by the attacks of the hibernating adults even before the larvae appeared. By the middle of August practically all of the leaves of every alder bush in the township had been skeletonized by the larvae, and the trees looked brown and bare, as though they had been swept by a fire. Many of the leaves had dropped from the trees, forming a mat half an inch or more thick under alder clumps. Some idea of the abundance of these insects may be obtained from the following data, which represent typical cases, illustrative of the condition of all of the shrubs in an alder copse covering several acres: on a twig selected at random, on which only the three last leaves were left, were found 115 larvae, 31 on the terminal leaf, and 56 and 28 respectively on the other two; on a single large leaf close by were counted 77 larvae. By the first of September the trees were practically leafless. The majority of them had put out new leaves which were eaten by the beetles as fast as they were produced. Such a serious infestation killed many of the trees even in a single season.

In the summer of 1915, there was a great reduction in the number of the beetles, and although they were still common locally, their range was so much restricted, that the writer knew but few localities in the whole township where he could obtain these insects. They were so rare in 1916 that even with diligent searching the writer found no larvae and only a single adult in Orono, and this condition seemed to be typical of that prevailing all over the state.

The writer can offer no satisfactory explanation of this extraordinary disappearance. It certainly was not due to any failure of the food supply through over-population, nor was it due to the activities of natural enemies, for the parasitic forms preying upon these insects were not sufficiently abundant to cause a wholesale destruction, and they are but little troubled by birds. Climatic conditions in the winter of 1914–15 were

far from favorable, yet this can hardly be postulated as the cause of their disappearance, as it seemed to have little if any effect on the abundance of other species of *Altica*. The summer of 1915 was a favorable one for the growth of fungi, and many larvae and some adults were killed in this fashion, but the alder flea-beetle is not more suspectible to fungous attacks than other members of the genus whose numbers remained undiminished. However this species was much more abundant than any of the others, and on that account fungus could work much more effectively. Undoubtedly the fungus played a large role in checking the outbreak.

There is one peculiar circumstance which should be noted in this regard, as it seems to be correlated with the disappearance of *A. bimarginata*. As is pointed out under another heading, most of the eggs of these flea-beetles are deposited within the leaf-rolls of an alder caterpillar,*Acrobasis rubrifasciella* Packard. So far as the writer has observed, the abundance of this larva on the alder almost parallels that of the alder flea-beetle. It was abundant in 1912 and 1913, and very abundant in 1914; it was somewhat less common in 1915, and scarce in 1916. Whatever may have been the complex of conditions acting as determinative factors, the same conditions which acted as a check on the abundance of *Altica bimarginata* Say apparently acted also as a check on *Acrobasis rubrifasciella* Packard, and the abundance of the two species was evidently closely correlated.

Fortunately these beetles are not yet of great economic importance. The alder is not used commercially, and so long as the depredations are confined to it, the beetles cause no great injury, except where the alders have been used for ornamental planting in landscape gardening. But as is pointed out later, they can live on willow and probably on balsam poplar; and whenever this species is abundant, there is always the possibility that it may become a serious pest, should the beetles transfer their ravages either to the willow or to the poplar, both of which are of commercial importance.

THE LIFE HISTORY OF THE INDIVIDUAL.

Summary of the Life History.

The adult *Altica bimarginata* is a dark shiny steel blue flea-beetle, which can be distinguished from all other species in our fauna by the longitudinal plica or fold on the side of the elytra. Like the greater number of other chrysomelids, these beetles hibernate as adults; in Maine they seek winter quarters in late September, and emerge in the spring as soon as the alder leaves, on which they feed voraciously, are well expanded. Pairs may be taken in copulation from the first of June until early July. From mid-June until late July the females deposit clusters of yellow eggs on the foliage which hatch in a few days into grubs or larvae which skeletonize the leaves. The larval life extends over a period of about 25 days, during which they molt twice; there are, therefore, 3 larval instars. When the grubs are full grown, they enter the ground and construct a rude cell, in which they pass about 6 days as prepupae and 10 days as pupae. At the end of that time the adults appear. Before they seek hibernating quarters, the beetles feed freely on the leaves of the alder, which is the preferred food-plant of this species. There is but one generation each year.

Seasonal History and Biological Data.

DURATION OF THE EGG STAGE.

A record which was kept of 476 eggs deposited between June 16 and July 20, inclusive, may be tabulated as follows:

87 hatched in 7 days; 207, in 8 days; 157, in 9 days; 25, in 10 days; average 8.3 days.

LENGTH OF THE FIRST LARVAL INSTAR.

A record which was kept of 425 larvae which hatched between July 13 and July 28 inclusive, may be tabulated as follows:

182 molted to the second instar in 5 days; 115, in 6 days; 31, in 7 days; 18, in 8 days; 73, in 9 days; 6, in 10 days; average 6.3 days.

LENGTH OF THE SECOND LARVAL INSTAR.

A record which was kept of 340 larvae which molted to the second instar between July 18 and July 30 inclusive may be tabulated as follows:

65 molted to the third instar in 7 days; 210, in 8 days; 65, in 9 days; average 8.0 days.

LENGTH OF THE THIRD LARVAL INSTAR.

A record which was kept of 95 larvae which molted to the third instar between July 27 and August 30 inclusive may be tabulated as follows:

5 entered soil in 9 days; 11, in 10 days; 3, in 11 days; 11, in 12 days; 4, in 13 days; 38, in 14 days; 11, in 15 days; 12, in 16 days; average 13.2 days.

LENGTH OF PREPUPAL PERIOD.

A record which was kept of 215 prepupae which entered the soil between August 7 and August 30 inclusive may be tabulated as follows:

9 pupated in 4 days; 19, in 5 days; 82, in 6 days; 56, in 7 days; 11, in 8 days; 11, in 9 days; 6, in 10 days; 8, in 11 days; 6, in 12 days; 3, in 13 days; 2, in 14 days; 0, in 15 days; 1, in 16 days; 0, in 17 days; 1, in 18 days; average 7.0 days.

LENGTH OF THE PUPAL STAGE.

A record which was kept of 34 pupae which transformed between August 11 and September 6 inclusive may be tabulated as follows:

2 adults emerged in 8 days; 7, in 9 days; 1, in 10 days; 18, in 11 days; 5, in 12 days; average 10.2 days.

VARIATIONS IN THE REQUIRED TIME.

It was observed that whether the eggs were deposited early or late in the season had no bearing on the number of days occupied by the different instars, nor did the length of any given instar affect the length of the next instar. However, if the third instar were of short duration, the prepupal period tended to be longer than normal, and conversely. The principal factors causing variation were the conditions of temperature and moisture.

Nevertheless there is great variation in the length of time which different individuals require for reaching maturity. This is true even in the case of larvae hatching from a single egg cluster, or from different egg clusters but on the same day. For example, from eggs which hatched on July 17, 11 prepupae were obtained on August 11, 25 on August 13, 4 on August 14, and 11 on August 15; 9 pupae were removed on August 17, 5 on August 19, 4 on August 20, 1 on August 21, and 1 on August 22.

The following is cited as a typical life-history:
6 eggs which were deposited on July 22 (1914) hatched on July 30.
The larvae molted to the second instar on August 11.
The larvae molted to the third instar as follows:
1 on August 19; 1 on August 21; 2 on August 23; 2 on August 24.
The larvae entered the soil as prepupae, as follows:
1 on August 27; 1 on August 28; 1 on August 31; 3 on September 1.
Pupae were formed as follows:
3 on September 3; 2 on September 5; 1 on September 6.
Adults emerged as follows:
1 on September 13; 1 on September 14; 1 on September 15; 2 on September 16; 1 on September 17.

SEASONAL HISTORY IN MAINE.

The earliest date on which the writer has found eggs of the alder flea-beetle in Maine is June 16 (1915), but since he has collected recently hatched larvae on June 18 (1915), eggs must be deposited at least as early as June 10. The maximum period of egg deposition is early July. The latest date on which eggs were deposited in the laboratory is July 29 (1915), when only three eggs were obtained from many females which had been ovipositing freely. No unhatched eggs were found in the field at a later date. The oviposition period extends over a period of about a month and a half: from mid-June until late July.

Just hatched larvae were common on June 20 (1915). Larvae may be found commonly in the field as late as mid-August in years when this insect is abundant. No larvae have been found in the field later than August 24 (1914), although the writer has had them in the laboratory as late as August 30 (1914). The great majority of the larvae become full grown in late July or the first half of August.

The earliest date on which the writer has obtained pupae of this species is August 5 (1914). Without doubt this is much

too late to be representative. Larvae entered soil in the laboratory on July 25 (1914), and if they had been allowed to develop should have formed pupae on July 31. Eggs deposited on June 10 should produce pupae on July 21 since 41 days is the average length of time required between the deposition of the eggs and the pupal transformation. This estimate is probably not far from correct, as eggs deposited on July 4 (1915) yielded pupae on August 13 (40 days). The majority of these insects pass through the pupal stage in August; the extreme records which the writer has for just-formed pupae are August 5 (1914) and September 6 (1914). As was pointed out, July 21 would doubtless be nearer the range of possibilities than August 5.

Nearly all of the hibernating adults are dead by late July. The latest date to which one lived in the laboratory is August 17 (1914). Adults become common again about the middle of August, and this undoubtedly represents the appearance of a new generation of the beetles. No adult which was bred in the laboratory emerged earlier than August 20 (1914), but pupae formed on July 21 should give adults on August 1. The extremes of emergence are probably represented by August 1 and September 7.

There is only one generation each year. There is no tendency to pair among the individuals of the new generation, and there is no indication that any of the pupae live over in the soil until the following summer. Since they pupate very near the surface in only the rudest sort of a cell, and since the pupal life normally lasts but a few days, one would not expect any of them to winter over. In the laboratory it was clear that all of the pupae which did not transform were unhealthy.

The writer was not able to make personal observations as to the time when the beetles seek winter quarters in the fall, and come out from their hibernating places in the spring. From the data to which he has access, it seems probable that in Maine the adults enter their winter hiding places early in October, and desert them in the spring as soon as the leaves of the alder are well expanded. Both in the fall and in the spring, the beetles feed freely on the foliage.

Description of the Stages; Molting Habits and Coloration.

THE EGG.

Description. Pale orange; ovate-oblong; average length 1.25 mm., average width 0.45 mm.; surface densely marked with fine pits. The egg is shown in figure 23.

Manner and place of deposition. Whenever it is possible, the eggs of this beetle are deposited within the larval tubes of *Acrobasis rubrifasciella* Packard, a leaf-rolling caterpillar of the family Pyralidae, which is often very common on the alders in Maine. The eggs are laid in the innermost part of the folded leaf, so that they are completely hidden and the leaf must be unrolled to expose them. Usually the eggs of *Altica* spp. are streaked with excrement by reason of an instinct which probably has arisen in connection with concealing them; occasionally the eggs of *A. bimarginata* are so streaked, but usually they are not, probably because, since the eggs are already so well protected, such an instinct is unnecessary and has been lost. In a few instances the writer has found the eggs deposited on the under side of a leaf; in such a case they were always placed next to one of the larger veins. In the laboratory, the beetles deposit eggs freely without any attempt at concealment. When first deposited, the eggs are soft and in color dark yellow, but they become bright orange as they harden, and by 24 hours they become the characteristic pale orange. Usually but not always the eggs turn dull gray 24 hours before they hatch.

The eggs are always deposited in clusters, never singly; a count of 90 clusters gave the following data (v stands for variant, or the number of eggs per cluster, and f for the frequency with which that variant occurred):

v	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
f	6	7	12	9	16	10	7	9	5	3	3	1	1	0	0	0	0

(v)	19	20	21	22
(f)	0	0	0	1

This shows 6 as the mean of the species, and gives 6.6 as the real average.

Hatching. Before the egg is ready to hatch, the shell becomes very brittle, and usually the egg turns grayish 24 hours previous to the emergence of the larva, although this is not always the case. Always, however, the lateral tubercles of the

mesothorax and the metathorax show prominently through the egg shell as 4 black spots 20 hours before the egg is ready to hatch. When the larva is ready to emerge, it makes 2 longitudinal slits near, but not quite at, the anterior end of the egg. The only chitinized portions of the cuticula at the time of the emergence are the dorsal halves of the lateral tubercles of the last 2 thoracic segments, and the writer believes that they are the instruments used in rupturing the egg shell. These tubercles show up very prominently in a newly hatched larva, as the chitinized portions are jet black, while all the rest of the body is bright yellow. The explanation offered above would account for this peculiar appearance, which is characteristic of the newly hatched larvae of all of the Alticini which the writer has observed.

The thorax is arched out through one of these longitudinal slits, sometimes the right one, sometimes the left. The presence of the second slit doubtless lessens the rigidity of the egg shell, and makes it yield more readily to the efforts of the larva in the process of hatching. This is accomplished merely by the regular contraction and relaxation of the body muscles. The mesonotum is the first part to protrude through the opening, then the metanotum and the pronotum, giving the larva a sort of hunch-backed appearance. After a long, hard process of similar, slow, regular, alternate contraction and relaxation of the body muscles, the larva finally succeeds in withdrawing its head from the opening. In 5 minutes, or even less time, after the head is free, the legs are drawn out, all almost simultaneously, and the larva walks out of the shell.

This process was observed several times. The time required from the appearance of the first break in the shell until the larva was entirely free varied from 28 to 39 minutes; it usually occupied about 30. The following example is cited as a typical case: 10.05 first break in the egg shell; 10.10 second break in the egg shell; 10.20 metanotum and mesonotum exposed; 10.25 pronotum exposed; 10.31 head free; 10.33 prothoracic legs drawn out; the other legs freed almost simultaneously; 10.35 larva entirely out of the shell.

THE LARVA.

Description of the full grown larva. Head, thorax, and abdomen distinct; abdomen composed of 10 segments; pronotum and dorsum of 9th abdominal segment strongly chitinized

to form the prothoracic and anal shields respectively; one pair of jointed legs borne by each of the thoracic segments; a single median anal proleg borne by the 10th abdominal segment. Length 1 cm.

Head directed obliquely downward and forward; strongly chitinized, shining black; the *epicranial suture,* at first extending cephalad along the mesal line, soon splits, passing back of the antenna to the base of the mandible on each side; it divides the head into three large segments, the median dorsal one the *postclypeus,* and the other two forming the *epicranium;* the *clypeus* is very narrow; *labrum* moderately large, rounded in front, shining black; *mandible* dark brown, moderate in size, with notched teeth at the apex; *trochantin* present at its base, non-chitinized; *maxilla,* with the cardo completely, the stipes incompletely, chitinized, bearing anteriorly a palifer with a 3-segmented conical palpus, and a very small nodule which probably represents the lacinia; *labium* with a large slightly chitinized basal piece, the fused mentum and submentum, bearing a ligula, unchitinized except at its base, from which arise a pair of small 2-segmented palpi; *antennae* inserted on the side of the head near the base of the mandibles, 3-jointed, white, the basal segment much larger than the middle segment, and the distal segment very small; *ocelli* wanting, the large sclerite between the labium and the prothorax (figure 18 B and C) is the *gula.*

Body wall of thoracic and abdominal segments brownish, densely beset with dull black cuticular nodules; prominent dull black dorsal, dorso-lateral, and lateral tubercles; ventro-lateral and ventral tubercles dull brown.

Abdominal segments 1 to 8 bear setiferous tubercles, segments 1 through 7 being identical; on the first 7, the setae are arranged in a mid-dorsal row of 2 tubercles on each segment (the anterior the larger), an upper and a lower row of dorso-lateral tubercles above the spiracle (each row composed of 2 small tubercles on each segment), a lateral row of prominent tubercles just below the spiracle (one tubercle to each segment), an upper and a lower row of ventro-lateral tubercles (a single tubercle each, on each segment), and a median ventral row (a single tubercle on each segment); on the 8th, the arrangement of the tubercles is the same except that the posterior of the mid-dorsals is the larger, and the upper and lower posterior dorso-lateral tubercles have united into a single one.

Abdominal segment 9 is modified dorsally into a strongly chitinized anal shield; ventrally it bears a large median tubercle, not clearly homologous with the other abdominal tubercles.

Abdominal segment 10 is very small; it has no setae nor tubercles, but bears ventrally the orange-yellow anal proleg (which probably represents the fusion of a pair of prolegs); the anal opening is shaped like an inverted Y, and lies in the middle of the proleg.

Metathorax and mesothorax. Mid-dorsal tubercles are present, homologous with those of the abdominal segments; they are broken along the mesal line (to provide a thin place where the cuticula can yield to strain.

and split at the time of molting); of the dorso-lateral tubercles, the 2 posterior have fused into one, the upper anterior is non-setiferous, and the lower anterior has fused with the lateral tubercle; the mid-ventral tubercles are present and homologous with those of the abdominal segments; but no other homologies can be drawn.

Prothorax. Modified dorsally into a strongly chitinized cephalic shield; the mid-ventral tubercle is the only tubercle which the writer can homologize with those of the abdomen.

Spiracles. There are 9 pairs of spiracles, 8 abdominal and one thoracic; the abdominal spiracles are borne on little tubercles located just above the lateral tubercles on segments 1 to 8; the thoracic spiracle is borne on a tubercle just above the base of the mesothoracic leg; an homologous tubercle, present on the metathorax, shows no indication of a spiracular opening.

Legs. The legs are composed of 5 segments, with an anterior and a posterior sclerite externally, at the base; the anterior sclerite is setiferous in the prothorax, and non-setiferous in the mesothorax and the metathorax; the posterior sclerite is setiferous in all 3 thoracic segments; the proximal segment is incompletely chitinized ectad, and almost not at all entad; it fits closely into a socket formed by the infolded body wall, with which it is continuous; the second segment, which is chitinized proximally, is barely visible ectad, but is much larger entad; the third segment, strongly chitinized ectad, is about equal in size to the second segment; the strongly chitinized fourth segment is the longest of the leg segments; the short, strongly chitinized distal segment bears a single pulvillus and a single inward-curved claw. The setae are the same on all of the legs, except that the proximal segment of the prothoracic leg lacks the anterior seta borne on the ental surface of the mesothoracic and metathoracic legs. There is no homology between the segments of the larval legs and those of the imago.

Figures. The arrangement of the setae and tubercles of the full grown larva is shown in the following figures: dorsal aspect, figure 18 A (head, thorax, abdominal segments 1, 8, and 9); ventral aspect, figure 18 B (head, thorax, abdominal segments 1, 8, 9, and 10); lateral aspect, figure 18 C (head, thorax, abdominal segments 1, 8, 9, and 10). The structure of the larval legs is shown in the following figures: ectal aspect, figure 20 A; ental aspect, figure 20 B (both drawings were made from mesothoracic legs). The structure of the larval mouth parts is shown in the following figures: labrum, figure 19 A; mandible, figure 19 B; maxillae and labium, figure 19 C. A first instar larva is illustrated in figure 24; a second instar, in figure 25; and a third instar, in figure 26.

Color changes of the larva during growth. The body wall of these larvae is covered with minute cuticular nodules, which together with the tubercles, are the pigmented portions of the body. Just after hatching or immediately after a molt, the integument is translucent, and the larva appears bright orange yellow, as no pigment has yet been formed, and the yellow fat-body

shows through. In a few hours pigment is formed in the tubercles and in the nodules. As the body wall is not stretched, the tubercles and the nodules lie very close together, and give the larva a dark aspect; late in the instar, the general color of the larva is much lighter, since the integument is stretched, the nodules farther apart, and the tubercles smaller in proportion to the body surface.

Such a series of color changes is very characteristic of all of the species of *Altica* which the writer has studied. They are either white or yellow after a molt (according to the color of the fat-body), as there is no pigment in the cuticula; they rapidly become darker, and the darkness is at a maximum a few hours after the molt; they become gradually lighter throughout the instar, and the coloration of the early and late part of the same instar is quite different in some species.

Description of the newly hatched larva. The coloration and setal arrangement (with the exceptions noted below) is the same in the newly hatched larva as it is in the mature larva; however the tubercles are proportionately much larger, and the cuticular nodules much closer together. The setae are distinctly capitate all through the first instar.

There are only 3 setae on the lateral tubercles of the mesothorax and the metathorax, instead of 4, as in the full-grown larva; and only 2 on the lateral abdominal tubercles instead of 3; and only one on the posterior dorso-lateral tubercles of the 8th abdominal segment instead of 2.

This condition is characteristic of the second instar larvae as well as those of the first instar; and not infrequently this same condition prevails in a full grown larva.

Head measurements of larvae.

1st instar.

Minimum	.38 mm.	
Maximum	.43 mm.	
Mean	.43 mm.	(21 specimens.)
Average	.42 mm.	(42 specimens.)

2nd instar.

Minimum	.64 mm.	
Maximum	.71 mm.	
Mean	.64 mm.	(5 specimens.)
Average	.67 mm.	(10 specimens.)

3rd instar.

Minimum	.86 mm.	
Maximum	1.05 mm.	
Mean	1.00 mm.	(29 specimens.)
Average	1.00 mm.	(81 specimens.)

Ratio of measurements: 1.6.
Theoretical measurements: .42; .67; 1.07.
Actual average measurements: .42; .67; 1.00.
Actual mean measurements: .43; .64; 1.00.

Coloration after hatching. When the larva hatches from the egg, it is entirely bright shining orange yellow, except for the lateral tubercles of the mesothorax and the metathorax, which show up very conspicuously in contrast to the rest of the larva, as 4 black dots. As has already been pointed out, there is no pigment in the cuticula except in these tubercles, and the general color of the fat-body shows through. It is a general rule in the coloration of *Altica* larvae of all species that those parts which are darkest in the fully colored larva, are the last to show signs of coloration in a recently molted specimen.

The coloration of the larva after it emerges from the egg is typically that outlined below: 20 min. abdomen darkish, head somewhat dull; 30 min. mesothorax and metathorax darkish above like the abdomen, head and pronotum still quite bright shining yellow; 45 min. head and pronotum blackish; 60 min. body all blackish and duller, lateral tubercles of the mesothorax and the metathorax less conspicuous; 75 min. body uniformly dull and darkish above, the tubercles darker than the body, and the head and legs darker than the tubercles; 90 min. no change; 120 min. head and legs darker, somewhat shining; 135 min. legs deep shining black, body decidedly dark, tubercles black but not shining, head and prothorax deep shining blackish yellow; 150 min. head and pronotum deep shining black. The lateral tubercles of the mesothorax and the metathorax continue darker than the others for about 24 hours.

Color description of a first instar larva, early.

Head, prothoracic and anal shields, and legs, shining black; general body color dark brownish black dorsally, somewhat lighter ventrally; dorsal and lateral tubercles black, not shining; ventral tubercles dark brown.

Color description of a first instar larva, late.

Head, prothoracic and anal shields, and legs, shining black; general body color dark golden yellow dorsally, lighter ventrally; dorsal and lateral tubercles dark brown; ventral tubercles golden yellow.

The molt to the second instar (first molt).

This molt is performed in exactly the same way as the molt to the third instar, and the process is described in detail under that heading. Numerous larvae were observed as they underwent the first molt; it required from 35 to 50 minutes to complete it.

Coloration after the first molt (second instar).

The coloration of the larva after the first molt does not differ from the coloration after the second molt, and is described in detail under the latter heading.

Color description of a second instar larva, early.

Head, prothoracic and anal shields, and legs, shining black; general body color brownish black dorsally, lighter ventrally; dorsal and lateral tubercles dull black; ventral tubercles but little darker than the body.

Color description of a second instar larva, late.

Head, prothoracic and anal shields, and legs shining black; general body color very dark golden brown dorsally, somewhat lighter ventrally; dorsal and lateral tubercles dark brown; ventral tubercles same color as the rest of the underparts.

The molt to the third instar (second molt). As is the case with arthropods in general, when the larva is ready to molt, a new cuticula is formed underneath the old one, and late in each instar, the old cuticula becomes very brittle. In the process of molting, it cracks first along the mid-dorsal line of the metathorax, the slit extending cephalad along the mid-dorsal line of the other thoracic segments, and the V-shaped epicranial suture of the head. During this time the larva is firmly attached to the leaf by the legs of the skin which is being shed, the tarsal claws of which are securely imbedded in the tissues, and by the anal proleg, which projects out a little beyond the old cuticula. By slowly and regularly contracting and relaxing the body muscles, the larva works its way out of the old skin; first the thorax is arched out and then the head is freed. The legs are drawn out almost immediately after the head, but as they are soft and weak, they are held closely appressed to the body, and the larva makes no attempt to walk for about half an hour. The insect is now attached to the leaf only by the anal proleg, and the old cuticula is left as a ring around 3 or 4 of the abdominal segments. This ring is finally pushed off over the anal proleg, mainly by the activities of the body muscles, although the legs are used a little at the end.

This molt was observed several times; a typical example is given below: 11.05 skin cracked along the metathorax; 11.15 head free; 11.17 legs free; 11.25 old cuticula left like a ring around the abdomen, which is about two-thirds free; 11.40 begins to walk; 12.05 entirely out of the old cuticula.

Coloration after the second molt (third instar). At the beginning of the molt, the larva, as it emerges from the old skin, is a pure orange yellow, except that the mandibles are reddish

brown and the setal punctures dark. In about 20 minutes the setal punctures show up black, and the cuticular nodules are just beginning to be pigmented, although a hand-lens is necessary to observe this. In about 40 minutes the body has a general dullish cast, but the head, legs and prothoracic shield are still bright yellow. (The legs are always a paler and more translucent yellow than the rest of the body, probably because they contain less adipose tissue.) In about 50 minutes the distal segments of the legs have a dark cast.

The following figures refer to the time when the larva was fully free from the old cuticula, and the molt complete: 10 min. body and prothorax darkish, the tubercles not darker than the rest of the body, head still yellow, legs duller; 20 min. no change; 30 min. body not quite as dark as the prothoracic shield, distal segments of the legs blackish and the other segments dull, head somewhat dull; 40 min. body about the same color, head as dark as the body but not as dark as the prothoracic shield; 50 min. prothoracic shield blackish at the sides, head dull darker than the body, legs still light except the distal segments; 65 min. prothoracic shield dark brown; head, legs, and tubercles brown; general aspect of the body dark yellow brown; 95 min. little if any change; 110 min. head black, legs dark brown the distal segments black, prothoracic shield black, tubercles dark brown; 140 min. normal coloration;

Color description of a third instar larva, early.

Head, prothoracic and anal shields, and legs shining black; general body color very dark brown, almost black (aspect black dorsally and dark dull golden yelow ventrally); lateral and dorsal tubercles dull black; ventral tubercles brown.

Color description of a third instar larva, late.

Head, prothoracic and anal shields, and legs shining black; general body color very dark brown, almost black, dorsally, very dark golden yellow ventrally, much darker than earlier in the instar; dorsal and lateral tubercles black; ventral tubercles brown.

THE PREPUPA.

Formation of the pupal cell. In all insects which undergo a complete metamorphosis, the wings are developed internally in the larva, as hypodermal invaginations; then a part of this invagination evaginates, forming the wing-bud proper; just before the formation of the pupal cuticula, this wing bud pushes out so as to lie outside the hypodermis; finally the pupal cuticula is secreted around it, and thus it is brought about that the internal wing-bud of the larva is external in the pupa. The period from the outpushing of the wing-bud in the larva until the molt to the pupa is spoken of as the prepupal period.

In the alder flea-beetle, the prepupal period is passed in the earth. As soon as the larva is fully fed, it enters the ground to complete its transformations. Sections of specimens fixed at this time show clearly that the entrance into the soil closely corresponds with the outpushing of the wing-buds.

In nature, as Lintner (1887) pointed out, the insects prefer to pupate under the mossy edge of a half-sunken rock, and the majority of the pupae are probably to be found in such situations. But even under natural conditions they will enter any fairly loose soil, pupating about an inch below the surface of the ground. The larvae construct a rude cell by contortions of the body, and the earth lining it is cemented together by a mucous secretion, probably poured out by the maxillary glands. (Labial glands, the ordinary salivary glands of insects, are entirely wanting in this species, as in Coleoptera generally.) The earlier prepupa is straight and can walk, but by the third day the body is strongly arcuate, and the insect is unable to move the legs. This is due to the degeneration of the larval muscles, for, as has been pointed out already, there is no relation between the larval legs and the imaginal legs. The latter are developed as knobs or pads at the bases of the larval legs, and do not project down into them, so that when the larva molts to the pupa, the larval legs are simply hollow shells.

Color changes of the prepupa. In several species of this genus, there is a distinct prepupal color cycle, the insect first becoming darker and then very much lighter in color. So far as the writer has observed, there is no change in the coloration of the prepupa of the alder flea-beetle.

THE PUPA.

The molt from the prepupa to the pupa. When the prepupa is ready to molt to the pupa, the larval cuticula cracks along the thorax as in an ordinary molt (beginning at the mid-dorsal line of the metathorax and extending forward) and the pupa gradually wriggles out by slowly contracting and relaxing the body muscles. The larval skin passes off over the caudal end of the body, where it may hang for several hours. At the beginning of the molt, each leg, though fully formed, is curled up into a little pad at the base of the larval leg, but as soon as they are free from the old cuticula they are straightened out so as to lie

in the position normal to the pupa. The wings and elytra lie pushed ventrad beneath the old larval skin in about the same relations that they show in the pupa. The pupa is always formed with the ventral aspect uppermost, and it remains in this position throughout this period.

Description. The general appearance of the pupa is that typical of the chrysomelids: wings and elytra pushed ventrad; the femora extending away from the middle line, the tibiae toward it, and the tarsi caudad along the mesal line; the metathoracic legs passing under the wings; the antennae extending caudad, bent under the mesothoracic legs.

There are 9 abdominal segments (unless the anal plate may be counted as a vestigial 10th), the last bearing a pair of strong black caudal spines. The arrangement of the setae is that characteristic of the genus *Altica*, and does not present any specific characters. The only specific variation which the writer has noted in the pupal setae of the genus *Altica* is the number of setae present on the femora. Sometimes there are 3, and sometimes but 2. In *A. bimarginata* there are 3: a pair of pre-apical setae and one apical, on each femur.

Great variation prevails in the setae which may be present in any individual specimen. Any given seta may be wanting (though the writer has never found a pupa in which any of the head setae were absent), and certain extra setae are sometimes present on the thoracic segments. The greatest variation is to be found in the pygidial setae. Very rarely the caudal spines themselves may be wanting entirely. Where the setae are serially homologous, and the arrangement the same on both sides of the body, as on the abdomen, a seta missing on one segment is usually present on the others, and may be absent only on one side.

The setae occur only on the dorsal aspect of the body and serve to keep the insect from contact with the sides of the pupal cell, as it lies with the ventral aspect uppermost.

The average length of the pupa is 5 mm.; the average width is 2.5 mm.

When formed, the pupa is bright orange yellow, with the appendages a more translucent yellow; the setae are brown, and the caudal spines and the spiracles (which occur on the first 6 abdominal segments) black. Packard (1890) described the pupae as white, but this is without doubt a mistake. Lintner

(1887) corrected this statement, suggesting that Packard's description might have been made from an alcoholic specimen, or that just formed pupae might possibly be white. The context precludes the former explanation, and as has just been stated, the newly formed pupae, like the older ones, are yellow. Essig (1915) stated that the pupae are either white or yellow, but this statement is probably incorrect. The writer has spoken of this at length because *bimarginata* pupae may be distinguished from certain other *Altica* pupae which are white, by the color characters, which are very constant. As the pupae of *bimarginata* do become white in alcohol, this distinction is useful only in the case of living pupae.

Figure 27 shows the dorsal aspect of the pupa; figure 28, the ventral aspect; figure 21 A, the arrangement of the setae, dorsal aspect, (mesothorax, metathorax, abdominal segments 1 through 8); figure 21 B, the arrangement of the setae, ventral aspect; figure 21 C, the setae of the 8th abdominal segment and the pygidium; figure 21 D, the setae of the prothorax, dorsal aspect.

Color changes of the pupa. As has been stated, the pupa when formed is entirely bright orange yellow, except for the brown setae and the black caudal spines and the spiracles, which are also black. But as the pupa grows older, certain color changes appear, which are correlated with the internal metamorphosis, and furnish a good indication as to the age of the pupa. All other species of the Alticini and the Galerucini which the writer has studied show similar external evidences of the progress of the internal metamorphosis by the formation of pigment in the cuticula.

The first change is to be noticed in the eyes, which become light brown on the 4th or 5th day after the pupal molt. On the 7th day, as a rule, the eyes are dark brown, the wings light gray, and the tips of the mandibles red brown. On the 8th day, the eyes are black, the distal tarsal segments black, and the femorotibial joints black; the labrum, the tips of the mandibles, and the palpi are brown; and there are brown spots on the pronotum. On the last day of pupal life, in addition to these markings, the coxae and tibiae are black, and the head is brown between the eyes.

There is of course a considerable amount of individual variation as to the time required for the appearance of these

changes, even in pupae which have come from the same egg cluster, but the sequence of the changes and the pigmentations themselves take place very constantly.

The elytra do not become pigmented at all during the pupal period, although the true wings become dark gray or almost black; since the wings lie under the elytra, the latter appear as if they were colored gray, but if one lifts them up, it is clearly seen that they are uncolored.

Another point which should be noted is the fact that no pigment is deposited in the pupal cuticula. The imaginal cuticula begins to be formed on the 3rd or 4th day of pupal life, and all of the pigment is formed in this cuticula. The pigmented imaginal cuticula shows up very plainly inside of the sheaths of pupal cuticula which enclose them. The imaginal mouth-parts are not completely formed at the molt to the pupa, and the pupal sheaths are much larger than the organs developed within them.

THE ADULT.

Description.

"Oblong, subparallel, above blue or slightly bronzed, usually moderately shining, sometimes subopaque. *Antennae*[1] half as long as the body, piceous, joints 2-3-4 gradually increasing in length. *Head* feebly shining, frontal carina obtuse, tubercles usually well marked, a few punctures extending across the head above the tubercles and near the eyes. *Thorax* one-half wider than long, slightly narrower in front, sides feebly arcuate, the margin very narrow, disc moderately convex, the ante-basal transverse depression rather deep, slightly sinuous at the middle, reaching the sides and joining the marginal depression, surface distinctly alutaceous, sparsely punctulate, punctures more distinct near the apex and the front angles. *Elytra* distinctly wider at the base than the thorax, humeri distinct, umbone moderately prominent and with a slight depression within it, a prominent lateral plica begins at the umbone, extends parallel with the margin, curves toward the suture near the apex, surface alutaceous, the punctures fine and indistinct, not closely placed. *Body beneath* and *legs* blue black, shining, abdomen sparsely and indistinctly punctate. Length .20-.24 inches; 5-6 mm."

The above description is copied directly from Horn (1889).

The Maine forms are usually bright cobalt blue, but rarely they may be a greenish blue. The writer has never seen any bronzy or subopaque forms in the state. The lateral plica varies

[1]The italics are the writer's; there are no italicized words in Horn's description.

in prominence, but in all specimens which the writer has examined, it has been plainly in evidence.

Emergence of the adult. The pupa is as deeply pigmented as it will ever be about 12 hours before the emergence of the adult. The coloration has already been described on page 266.

About half an hour before the emergence, the mouth-parts are moved continually. The pupal cuticula first splits along the mid-dorsal line of the mesothorax; then this crack extends backward down the mid-dorsal line of the metathorax, and forward along that of the prothorax. This split is made by the scutellum, which is moved up and down until the cuticula is ruptured. Within 20 or 30 minutes after the crack has appeared, the head and mouth-parts, as well as the whole pronotum, have been freed from the pupal cuticula. The elytra and wings, which have increased to their full length, have been pushed nearly dorsad. The prothoracic legs project out on each side, strongly bent at the femoro-tibial joint; the mesothoracic legs extend straight down the body, as do also the metathoracic pair, which have been drawn from under the elytra. The antennae lie straight down the middle of the ventral aspect, slightly bent in at their tpis, but entirely free from the legs. The abdominal muscles contract and expand rhythmically.

After the mouth parts have been freed, the beetles usually rest about 5 minutes, but soon recommence the task of molting. The next step is to withdraw one of the prothoracic legs from its pupal sheath, the other following almost immediately. At this point the antennae usually are drawn out: the head is inclined ventrally as far as possible, and then is suddenly thrown backward dorsally as far as is possible, and thus the antennae are pulled out of their pupal cases. Kicking and pushing with the tibio-tarsal joints of the front legs, the beetle rapidly succeeds in drawing out the mesothoracic legs and then the metathoracic legs from their pupal sheaths. The movements of the abdomen have pushed the pupal cuticula farther and farther caudad on the dorsal aspect of the body, and on the wings and elytra, so that by this time they are two-thirds free from the cuticula. The wings and elytra lie entirely dorsad. The pupal skin is now pushed downward and backward off the tip of the abdomen; the tibio-tarsal joints of all of the legs are used in this process which requires only a short time for its accomplishment.

The pupa is formed with the ventral aspect uppermost, and the adult remains on its back for about 4 hours after it has emerged. The beetle is of course very soft, and remains in the pupal cell, until it is fully hardened and colored, which requires about 24 hours.

The coloration of the adult. The beetle which has just emerged is quite as yellow as was the pupa. The eyes, antennae, and mandibles (sometimes also the labrum) are black, the elytra are grayish orange, and the wings gray. The insect becomes colored gradually, but it is some 20 hours before the characteristic coloration is reached. The beetle is entirely blackish above within 5 hours, and the underparts do not begin to color up at all until after that time. The centers of coloration are the pronotum, the ventral aspect of the pygidium, the bases of the elytra, the bases of the coxae, and the femoro-tibial joints of the legs.

THE RANGE OF FOOD PLANTS.

In nature, the alder flea-beetle is confined almost entirely to the leaves of the alder, at least in Maine, and the only other plant on which the writer has taken them is the willow (*Salix rostrata* Richards.)

There is a biological race of this species which occurs on balsam poplar, in Veazie, Maine. Eggs, larvae, pupae, and adults are indistinguishable from the typical *bimarginata*, and the larvae and adults eat alder or willow as readily as they do balsam poplar. The forms taken on alder however (both larvae and adults) have been tested many times on the leaves of the balsam poplar, but the results have always been negative. This is not surprising, when individuals which had already eaten alder were concerned, for the glandular leaves of the balsam poplar have a very decided taste and smell, but just hatched larvae of the alder race which had never tasted any food were equally emphatic in their refusal to subsist on the balsam poplar. Both larvae and adults will feed freely on the leaves of willow; they ate the foliage of all species with which they were tested.

Nevertheless the writer feels very sure that these are only biological races of the same species, if they deserve even that distinction. The habits, size, appearance, and life-history of the variety on the balsam poplar are exactly the same as that described for the alder forms, save that the eggs are deposited

in clusters on the under side of the leaves. Specimens were referred to Mr. C. W. Leng of New York City, who kindly determined them as undoubtedly *Altica bimarginata* Say.

All of the data on pages 253-270 appertain to the alder race.

Gibson (1913 p. 6) recorded this species as feeding on alder, willow, and poplar. Essig (1915 p. 266) reported this insect from alder, willow, poplar, and cottonwood.

The following tables record a few food plant tests which were made with the larvae and adults of the 2 races. The tests were made as follows: 6 larvae or adults were kept in a clean shell-vial without food for 24 hours; then an uninjured leaf of the plant to be tested was introduced, and the insects were left undisturbed for a second 24 hours; at the end of that time the leaves were examined, and a record made as to whether they had been considerably eaten, slightly eaten, or left untouched.

Altica bimarginata. (Alder race.) Food-plants of adult.

(i) Eaten readily.
Willow, *Salix* sp. near *nigra* Marsh, *S. cordata* Muhl., *S. rostrata* Richards; alder, *Alnus incana* (L.) Moench.

(ii) Eaten slightly.
European gooseberry, *Ribes Grossularia* L.

(iii) Refused.
Balsam poplar, *Populus balsamifera* L.; gray birch, *Betula populifolia* Marsh; white elm, *Ulmus americana* L.; cultivated rose, *Rosa* sp.; wild red cherry, *Prunus pennsylvanica* L. f.

Altica bimarginata. (Poplar race.) Food-plants of adult.

(i) Eaten readily.
Willow, *Salix cordata* Muhl.; balsam poplar, *Populus balsamifera* L.; alder, *Alnus incana* (L.) Moench.

(ii) Eaten slightly.
White elm, *Ulmus americana* L.

(iii) Refused.
Gray birch, *Betula populifolia* Marsh; wild red cherry, *Prunus pennsylvanica* L. f.; red osier dogwood, *Cornus stolonifera* Michx.

Altica bimarginata. (Alder race.) Food-plants of larva.

(i) Eaten readily.
Willow, *Salix* sp. near *nigra* Marsh, *S. cordata* Muhl.; aspen pop- Richards; alder, *Alnus incana* (L.) Moench.

(ii) Refused.
Balsam poplar, *Populus balsamifera* L.; wild strawberry, *Fragaria virginiana* Duchesne; red osier dogwood, *Cornus stolonifera* Michx.

Altica bimarginata. (Poplar race.) Food-plants of larva.

(i) Eaten readily.

Willow, *Salix* sp. near *nigra* Marsh, *S. cordata* Muhl.; aspen poplar, *Populus tremuloides* L.; balsam poplar, *Populus balsamifera* L.; alder, *Alnus incana* (L.) Moench.

The form of the scientific names and the sequence of the plant families in the above tables follows the use of the last edition of Gray's Manual.

The writer has found the following references to additional host-plants in the literature:

Alder. *Alnus serrulata* Willd. [Now classed as *rugosa* (DuRoi) Spreng.]

Harris (1869); Lintner (1887); Packard (1890).

Knotweed and smartweed. Blatchley (1910).

ACTIVITIES OF THE ALDER FLEA-BEETLE.

Feeding Habits of the Larva.

The larvae live exposed on the leaves of their food-plants, on either surface. In the case of the alder, when they first hatch they crawl to the petiole end of the leaf, where they feed for a few days protected under the slightly revolute margin. At first the larvae eat only the lower epidermis and the green tissue, leaving the upper epidermis; but before this instar is over, they eat this epidermis also, leaving only a skeleton of the larger veins. This perfect and beautiful skeletonization, which has also been remarked upon by Harris (1869), Lintner (1887), and Packard (1890) is characteristic of all of the larval feeding, with the exceptions here noted; it is illustrated in figure 29. The nearly full grown larva eats holes through the leaves, as does the adult. The skeletonization is not as perfect on the leaves of the balsam poplar or the willow, as it is in the case of the larva. A balsam poplar leaf skeletonized by the larvae of *Altica bimarginata* is shown in figure 31.

The Feeding Habits of the Adult.

The adult beetles feed very freely on the leaves of the alder, eating little holes through them. This method of feeding, which is as characteristic as that of the larvae, is illustrated in figure 30. The adults feed both in the fall and in the spring. Willow and balsam poplar are attacked in the same way, and in no case do the adults ever skeletonize the leaves.

Copulation.

The male and female remain in copulation several hours. The writer has never observed them to pair more than once, but it is probable that they do, since this is quite characteristic of related species.

Number of Eggs Deposited by a Single Female.

The writer has very little data as to the number of eggs which one female may deposit. None of the females which he has isolated after pairing deposited more than 35 eggs. But related species may deposit as high as 500 eggs per female, and doubtless 35 is far too low even to approximate the number of eggs which one female *bimarginata* can deposit. They usually begin to oviposit within a few days after pairing.

NATURAL ENEMIES.

Fungous Enemies.

Both in the laboratory and in the field, larvae, prepupae, pupae, and adults are very susceptible to the attacks of *Sporotrichum globuliferum* Speng, if the conditions are right for infection. The writer does not doubt that this fungus played an important part in checking the outbreak of the alder flea-beetle, since it was abundant both in 1914 and 1915. While probably the fungus was not the only agent in the extermination of this species, nevertheless the extreme abundance of these insects offered ideal conditions for fungus to work, and doubtless great numbers of *Altica bimarginata* were destroyed in this way. Dr. Roland Thaxter of Harvard University kindly determined the species of fungus for the writer.

The pupae are quite subject to a wilt-disease, probably bacterial in its nature, but the writer has made no attempt to isolate the causative organism.

Insect Parasites.

An interesting parasite was bred from the adult beetles in the summer of 1915, a dipterous insect of the family Tachinidae, which was determined by Mr. C. W. Johnson of the Boston

Museum of Natural History as *Hyalomyodes triangularis* Loew. It was described under the generic name of *Hyalomyia* by Loew (1863, p. 85), and described again as a new species by Townsend (1893, p. 429), as *Hyalomyodes weedi*. The identity of the types was established by Coquillet (1897, p. 70), but he recognized *Hyalomyodes* as a distinct genus from *Hyalomyia*, and therefore the correct name stands as *Hyalomyodes triangularis* Loew.

The larvae are internal parasites of the adult beetles. The writer has no data as to the length of larval life, nor the manner of oviposition, but it seems probable that the eggs are deposited on the adult beetles in the spring or summer, after they have come out from hibernation. When the larva is full grown, it issues from the beetle, forcing its way out through the dorsal side of the abdomen, between the last two abdominal segments. The larva is white, with irregular brown splotches. In a few hours a brown puparium is formed, and the adult fly emerges about 2 weeks later.

1 puparium formed July 9, 1915; adult emerged July 21.....12 days.
1 puparium formed July 21, 1915; adult emerged Aug. 9.....19 days.
2 puparia formed July 26, 1915; adults emerged Aug. 9.....14 days.

The writer has not found any reference to the life-history of this species in the literature. *Celatoria spinosa* Coquillet, a related species which the writer has bred from the adults of 2 species of *Altica*, has been recorded by Coquillet (1890, p. 235) as bred from the adults of *Diabrotica soror* LeC.

CONTROL.

The writer has had no occasion to work on the control of these insects, but there is no reason to suppose that the measures employed in combating other flea-beetles would not serve to keep the alder flea-beetle in check, wherever their application was practicable. A thorough spraying with arsenate of lead at the rate of 3 pounds (paste form) to 50 gallons of water, as soon as the beetles appear in the spring, and repeated in late June and mid-July for the larvae, if necessary, would doubtless control this species.

THE SYNONYMY OF THE GENUS *ALTICA* GEOFFROY.

Altica Geoffroy 1762. Hist. nat. des. ins. t. 1, p. 244.
Haltica Illiger 1802. (Emend.) Mag. f. Insektenk. Bd. 1:138.
**Haltica* Hoffman 1803. (Emend.) Ent. Hefte.
**Graptodera* Chevrolat 1834. Cat. Dejean. ed. 2.

The systematic position of the flea-beetles was a matter of great dispute for about 50 years after Geoffroy had proposed the genus *Altica* to include them. A summary of the usages of the various writers from the 10th edition of Linnaeus' "Systema naturae" in 1758, which has been adopted as the arbitrary starting point for zoological nomenclature, to the final establishment of *"Haltica"* as a definite genus by Illiger in 1807, is given in the 2 tables published below. A more complete account of this history may be found in Kutschera (1859), Allard (1860), and Chapius (1875).

Authors who retained *Altica* previous to 1807.

*1762 Geoffroy p. 244; 1764 Geoffroy p. 244; 1775 De Geer p. 290; 1775 Fabricius p. 112; *1785 Fourcroy; 1789 Olivier p. 128; 1790 Olivier p. 100; 1796 Latreille p. 63; 1802 Illiger p. 138 *(Haltica);* *1803 Hoffman; 1804 Latreille p. 323; 1807 Latreille p. 63; 1807 Illiger p. 81 *(Haltica).*

Authors not retaining *Altica* previous to 1807.[2]

1758 Linnaeus p. 373 *Chrysomela* (Saltatoriae femoribus posticis crassisimis); 1763 Scopoli p. 69 *Chrysomela* (Saltatoriae); 1776 Fabricius p. 32 *Chrysomela* (Altica similis Chrysomelae saltatoriae Linn. certe huius generis); 1781 Fabricius p. 131 *Chrysomela* (Alticae saltatoriae femoribus posticis incrassatis); 1787 Fabricius p. 75 *Chrysomela* (Alticae saltatoriae femoribus posticis incrassatis); 1788 Linnaeus p. 1691 *Chrysomela* (Saltatoriae femoribus posterioribus incrassatis: Alticae); 1792 Fabricius t. 1, pt. 2, p. 24 *Galeruca* (Saltatoriae); 1801 Fabricius t. 1, p. 417 *Colaspis* (Saltatoriae), t. 1 p. 445 *Chrysomela* (Saltatoriae), t. 1 p. 463 *Crioceris* (Saltatoriae), t. 1 p. 477 Lema (Saltatoriae), t. 1 p. 491 *Galleruca*[3] (Saltatoriae femoribus posticis incrassastis); t. 1 p. 502 *Cyphon* (Saltatorii); t. 2 p. 57 *Cryptocephalus* (Femoribus saltatoriis).

Altica was proposed by Geoffroy in 1762 as a distinct genus to include the jumping chrysomelids which had been included by Linnaeus (1758) in the genus *Chrysomela*. The original definition of *Altica* was "Antennae ubique aequales, femur a postica crassa subglobosa" (p. 244), and as first constituted the genus included 19 species. In modern usage, as one would expect, the genus *Altica* is defined within much narrower limits,

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*The writer has not had access to this paper.

[2]The flea beetles are grouped at the end of the respective genera in which they are placed with the designation "saltatoriae" or some similar expression, as is indicated in the parentheses.

[3]The older authors spelled this word sometimes with one "l" and sometimes with 2. The genus was constituted by Geoffroy (1762) as *Galeruca* (p. 251), which is therefore the correct form. In this section of the paper the writer has indicated the spelling as it is to be found in the various papers quoted.

and the original genus has been split up into many smaller ones, so that *Altica* as we regard it today includes only a small portion of the species agreeing with Geoffroy's original description, which quite closely approximates our present conception of the tribe Alticini.

Geoffroy's (1762) discussion of the alticines is very interesting, and a translation, as literal as possible, follows: "To jump actively in the air with the agility of fleas is one of the peculiarities of the insects of this genus, a character which has given them the Latin name of *Altica*, or in French sauteurs, in place of the name Mordelles under which they have been described by some recent writers. We have reserved this latter name for some insects which constitute a different genus from this, although the two have been confused.

"To accomplish this active and considerable jump, nature has made the hind legs of the altise larger and stronger than the others. Especially the femora of these legs are remarkable. In almost all of these insects they are disproportionately large and often almost spherical, a character which makes them walk badly and slowly; but these great femora also enclose sufficiently strong muscles to execute such a violent movement as that which these animals make in leaping. We have drawn the character of the genus from the large femora and from the form of the atnennae which are quite long and of the same diameter throughout. The altises are all quite small. They are found in great quantities on potherbs, especially in the spring. They riddle and consume them. I have also found on these same plants numbers of small larvae, which may well be those of these altises, a thing which I do not dare affirm as I have not followed their metamorphoses."

There are 3 points which should be noted in conection with the paragraphs just quoted. First, the date which is usually assigned for the erection of the genus *Altica* is 1764; however, this is an error. The original date of publication of the Histoire d'insects by Geoffroy was in 1762, and the 1764 edition was a reprint. (The writer has had access only to the latter edition, and the page references given in this paper all refer to that printing, but as all of the page references to the 1762 edition agree with the pages as here given, it is probable that the pagination of the 2 is identical; such also is the inference one would draw from Hagen's Bibliotheca Entomologica.)

In the second place, Geoffroy proposed *Altica* to take the place of *Mordella* Linnaeus (p. 244). But Geoffroy was mistaken in stating that Linnaeus placed the flea-beetles in the genus *Mordella*. In the 1758 edition of the Systema naturae which has been constituted the standard from which binomial nomenclature dates, the flea-beetles were put in the genus *Chrysomela*

with the designation "Saltatoriae femoribus posticis crassissimis" (p. 373). Each species under this heading is described as "Mordella etc." and it is possibly this fact that accounts for Geoffroy's statement, but more probably it is because in the 1756 edition the flea-beetles are evidently included under *Mordella*, which is characterized as "Antennae filiformes, ultimo globoso. Pedes saepe saltatorii". But in 1758 and all of the later editions *Mordella* is used by Linnaeus for Coleoptera very distinct from the flea-beetles.

Finally, Geoffroy was also mistaken in saying that *Altica* was derived from the Latin. It is really derived from a Greek word, ἅλτικος, a leaper. As in Greek "h" is not a letter but is represented only by an asper, this omission of the "h" was a not unnatural error.

Illiger (1802) pointed out the proper derivation and corrected the speling. In his list of insect genera, we find: "Halticaae f Flohkäfer. ἅλτικος, zum Springen geschikkt. Nicht Altica." (p. 138). But this emendation cannot stand, for by Article 19 of the International Code: "The original orthography of a name is to be preserved unless an error of transcription, a lapsus calami, or a typographical error is evident" we must return to the first spelling, *Altica*. Hoffman (1803) also emended the spelling to *Haltica*, apparently independently (Chapius 1875, p. 16: the writer has not had access to Hoffman's paper). In this connection it is interesting to note the opinion of Allard (1860) who wrote long before the Code was drawn up: "It seems to me that the orthography of the word should be determined by priority, and since Geoffroy in 1762 and Fourcroy in 1785 wrote it with an 'A', with Latreille we must respect their right of invention and omit the 'H' " (p. 41).

It is unfortunate that it is necessary to make any change in the name of a genus so important, so well-known, and so firmly established as *"Haltica"*, but the change is such a slight one that there should but little confusion result. It is obvious that all of the larger groups of which *Altica* is the type genus must be changed in a corresponding fashion, Halticini to Alticini, Halticae to Alticae etc.

The English and German authors as a whole adopted the emended spelling as soon as it was proposed. The French however clung to the old spelling for many years. *"Haltica"* is the

spelling universally recognized today; the last systematic paper in which the writer has found the old spelling is Allard (1860). The word is probably spelled with an "A" in Allard (1867), a publication to which the writer has not had access

Chevrolat (1834) proposed the genus *Graptodera* as a substitute for *Altica* Geoffroy, omitting this genus entirely. (The writer has not had access to this paper: authority for statement Chapius 1875, p. 60.) This usage was followed by Allard and several writers. But Chapius (1875) pointed out the convenience of the term "Halticides" and the consequent necessity of preserving a genus *"Haltica"*. Kutshcera (1859), Fairmaire (1856) and Redtenbacher (1849) all retained *"Haltica"*. Since Chapius' work, it is fair to state that *Graptodera* Chevrol. has been reduced to the synonymy, and that *"Haltica"* has been recognized as a valid genus. The use of Illiger (1802) has been universally followed in the spelling, but this practice is inadmissible, and we must return to Geoffroy's original orthography, *Altica*.

The writer is not in a position to discuss the proper systematic position of the genus *Altica*, nor the proper rank to which its group should be assigned, but a brief summary of the development of the Alticini as a tribe (or according to some writers as a family) may not be without interest. A full discusion may be found in Kutschera (1859) and Chapius (1875).

The first attempt to divide the chrysomelids into groups seems to have been made by DeGeer (1775), who divided them into 4 families, *Altica* being the sole representative of the 4th family (p. 289). Latreille (1796) grouped various chrysomelid genera together as his 24th family (p. 63). Later (1804) he called this family the Chrysomelinae (t. 11, p. 323) and placed the genus *Altica* in it (t. 12, p. 5). In his next publication (1807) he recognized the same classification (p. 42 and p. 63). In 1810, he divided this family into the Criocerides (p. 232) and the Chrysomelinae (p. 235), retaining *Altica* under the latter (p. 235). This same plan was followed in 1817[1], but in 1825[1] he changed these names to Eupodes and Cycliques respectively. In 1830[1] he subdivided the Cycliques into 3 groups, Cassidaires, Chrysomelines, and Gallerucites, the last being further sub-

[1]The writer has not had access to this publication; authority for statement Kutschera (1859), p. 10–11.

divided into the Gallerucites isopodes with *Galleruca* as the type, and the Gallerucites anisopodes with *Altica* as the type.

Chapius (1875) recognized the Galerucides as a tribe, which he divided into 2 subtribes, the Galerucides proper and the Halticides. The latter he subdivided into 19 groups. Le Conte and Horn (1883) followed this use, recognizing the Galerucini as a tribe of the Crysomelidae, and dividing it into the subtribes Galerucini and Halticini. Horn (1889) has published the only monograph of the American Halticini (properly to be called Alticini). He found 14 of Chapius' 19 groups in America, and subdivided 3 of them into 2 groups each, so that he listed 17 groups of American Alticini. One of these groups which he subdivided was the "Halticae" of Chapius, which became the Disonychae and "Halticae" (represented in this country by the single genus *Altica)* of Horn.

Some recent authors have constituted the Alticidae as a separate family, but it seems best to the writer at least for the present either to regard the Alticini as a tribe under the family Chrysomelidae, or to follow the use of Horn and regard it as a subtribe of the tribe Galerucini.

The following characterization of the group Alticae and the genus *Altica* is copied directly from Horn's monograph (1889):

Alticae. "Antennae 11-jointed. Thorax regularly arcuate at the base, with a distinct ante-basal line variable in distinctness, not limited at the extremeties by a longitudinal plica. Posterior tibiae with, at most, a very slight sulcus on the posterior edge near the apex. Anterior coxal cavities open behind. Claw joint of posterior tarsi slender, claws appendiculate."

Altica. "Head short, usually deeply inserted, front regularly declivious, the interocular carina never prominent, the tubercles usually feebly masked. Anntenae half as long as the body, joints 2-3-4 gradually longer, except in *rufa.* Labrum small. Maxillary papli short, rather stout, the terminal joint short and conical. Thorax usually one-half wider than long and broadest at base, and with a more or less distinct ante-basal impressed line, base arcuate, lateral margin more or less thickened at the front angles. Elytra usually a little wider at the base than the thorax, the punctation of surface confused. Prosternum rather narrow between the coxae, the coxal cavities open behind, angulate externally. Legs moderately long, tibiae of posterior legs not or feebly sulcate, terminated by a small spur. Tarsi moderate in length, claws with a broad dilatation at the base."

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1860. Essai monographique sur les galerucites anisopodes (Latr.) ou description des altises d'Europe. Ann. Soc. ent. Fr. 1860. ser. 3, t. 8: 39–144, 369–418, 539–578, and 785–834.

[1]1867. Monographie des alticides. L'Abeille. 1866–67. t. 3:169. (Ref. Chapius 1875 p. 16).

Blatchley, Willis Stanley.

[2]1910. An illustrated catalog of the Coleoptera or beetles known to occur in Indiana (p. 1201).

Briton, Wilton Everett.

[2]1911. Vacation notes in the Adirondacks. Jour Ec. Ent. v. 4:544.

Bruner, Lawrence.

[2]1893. Insect enemies of ornamental and shade trees. Ann. Rpt. Neb. Hort. Soc. 1893, p. 166–235 (*alni*, p 205–206, fig. 46).

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1875. Histoire naturelles des insectes. Genera des Coleopteres. t. 11.

Chevrolat, Pierre Francois Marie Auguste, Comte.

[1]1834. *In* Dejean, Catalogue des Coleopteres, ed. 2. (Ref. Agassiz, Nomenclator zoölogicus. Chapius 1875, p. 61 and Kutschera 1859, p. 11, give this date as 1837).

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1775. Memoir pour servir d'l'histoire des insectes, t. 5.

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[1]Writer has not had access to this paper: reference unverified.

[2]This paper deals directly with *Altica bimarginata* Say.

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1787. Mantissa insectorum.
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1801. Systema eleutheratorum.

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1764. Histoire abregee des insectes....., ed. 2.

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Harris, Thaddeus William.

[2]1869. The entomological corespondence of Thaddeus William Harris. Edited by Samuel Hubbard Scudder. Occ. papers Bos. Soc. Nat. Hist. I *(alni,* p. 267–268).

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[1]1803. Entomologische Hefte.

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[2]1889. A synopsis of the Halticini of Boreal America. Trans. Am. Ent. Soc. 1889. v. 16:163–329.

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1804. Histoire naturelle..... des crustaces et des insectes. t. 11.

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1810. Considerations generales sur l'ordre naturel des animaux.....

[1]1817. Le regne animal. (Ref. Kutschera 1859, p. 10).

[1]1825. Familes naturelles. (Ref. Kutschera 1859, p. 10).

[1]1830. Le regne animal. ed 2. (Ref. Kutschera 1859, p. 11).

LeConte, John Lawrence.

[2]1857. Report of the Exploration and Surveys..... for a Railroad from the Mississippi River to the Pacific Ocean. v. 12. Report on the insects collected, p. 1–72, pl. 1–2. (*prasina*, p. 24, p. 67; *plicipennis*, p. 24.)

[2]1859. The Coleoptera of Kansas and Eastern New Mexico. (*ambiens*, p. 25; *subplicata*, p. 25).

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[2]1888. Fourth report on the injurious and other insects of the State of New York. p. 1–237. (p. 96–101).

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[1]1849. Fauna austriaca. Die Kafer nach der analytischen Methods bearbeitet.

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1763. Entomologica carniolica.....

Sturm, Jacob.

[1,2]1843. Catalog der Käfersammlung von J. Sturm. *(carinata,* p. 282).

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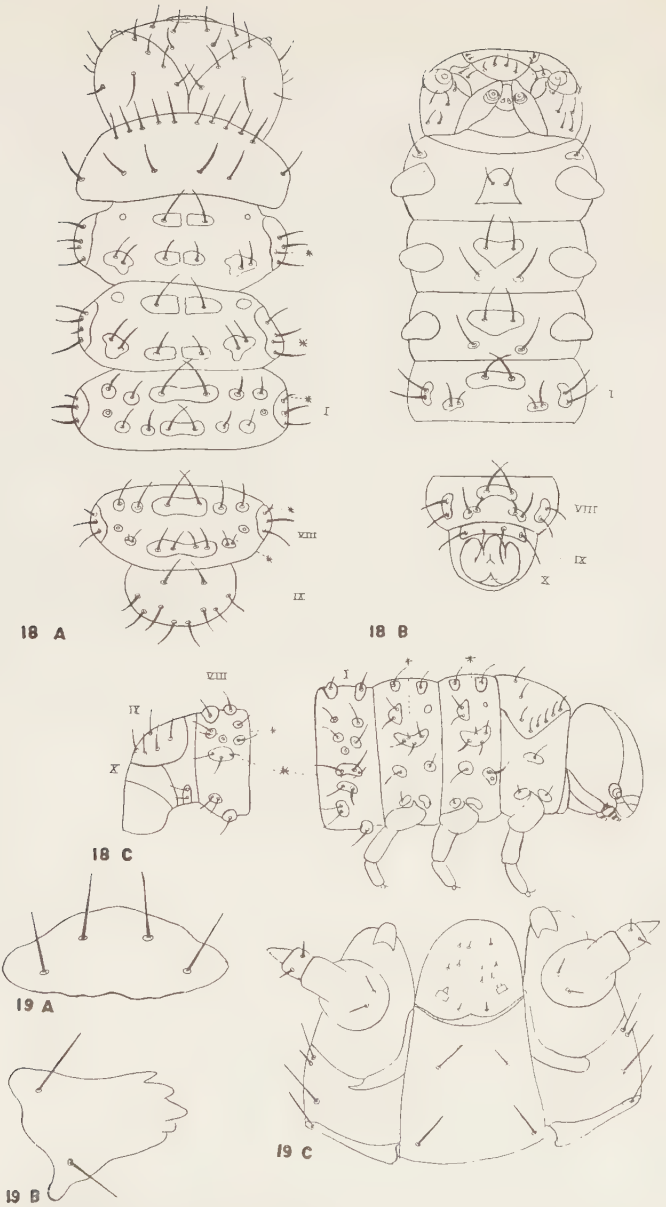
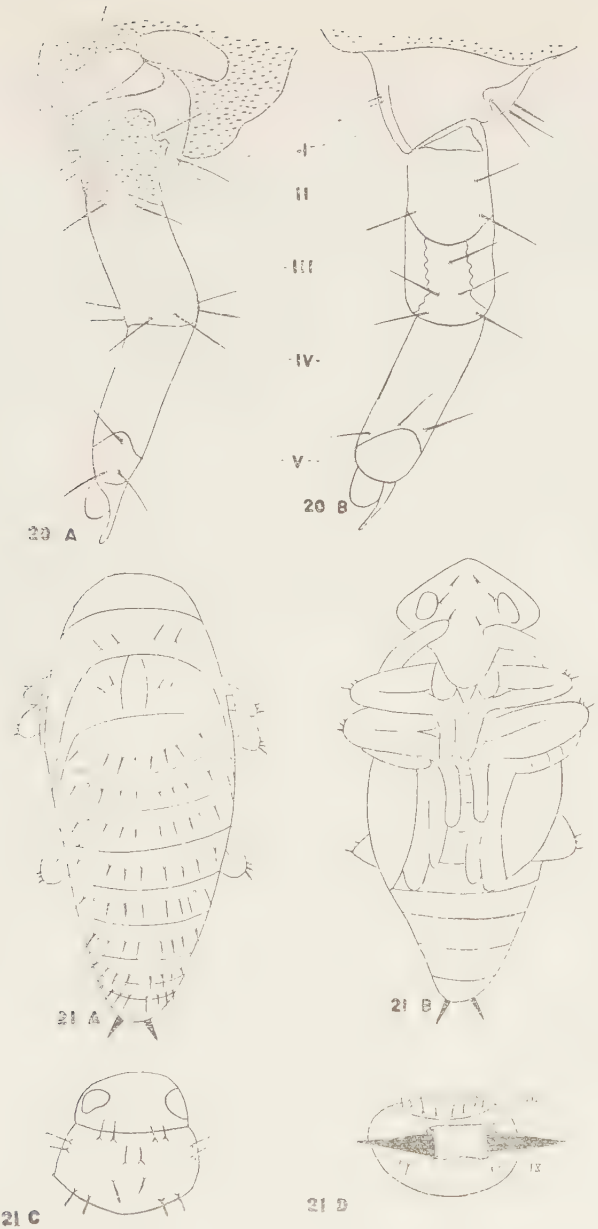
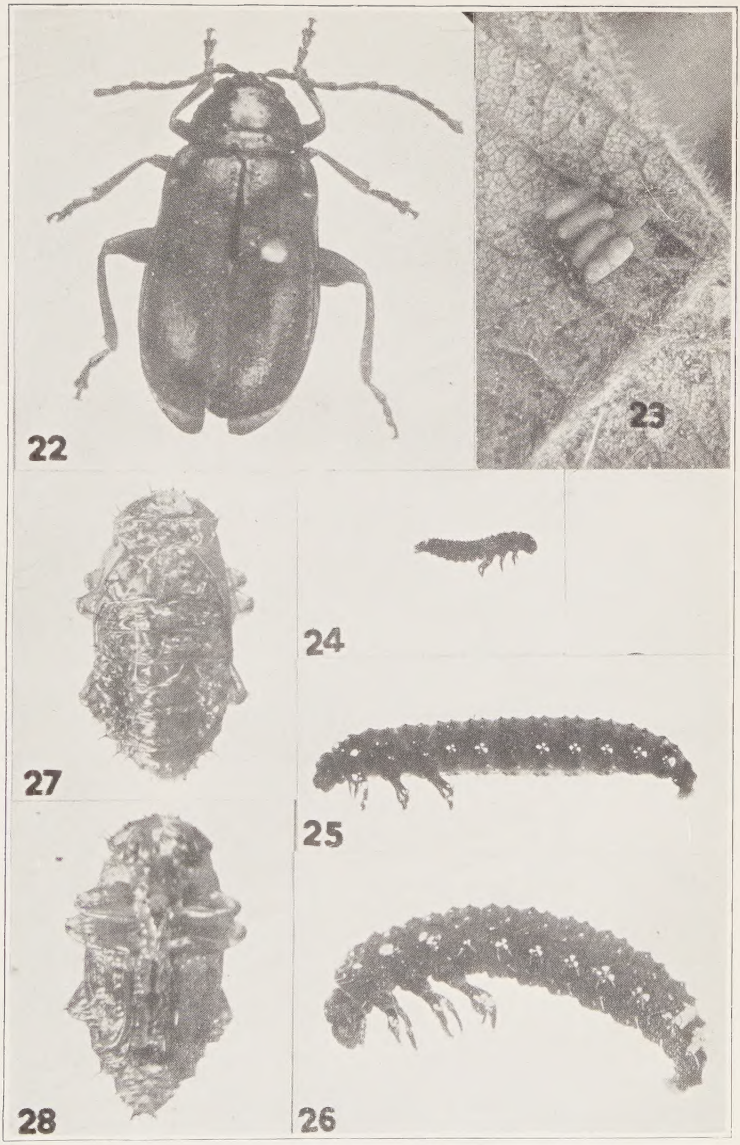


Altica bimarginata, larva. Fig. 18A: dorsal aspect, showing setae; fig. 18B: ventral aspect, showing setae; fig. 18C: lateral aspect, showing setae; fig. 19A: labrum; fig. 19B: mandible; fig. 19C: maxillae and labrum. For explanation see pages 258-260. Setae marked with an asterisk (*) are never found in first and second instar larvae and may be wanting in the third instar.



Altica bimarginata. Fig 20A: larval leg, ectal aspect; fig. 20B: ental aspect; fig. 21A: dorsal aspect of pupa, showing setae; fig. 21B: ventral aspect of pupa showing setae; fig. 21C: prothorax of pupa showing setae; fig. 21D: pygidium of pupa showing setae. For explanation see pages 260 and 265-267.



Altica bimarginata. Fig. 22: adult; fig. 23: eggs; fig. 24: 1st instar larva; fig. 25: 2nd instar larva; fig. 26: 3rd instar larva; fig. 27: pupa, dorsal aspect; fig. 28: pupa, ventral aspect.

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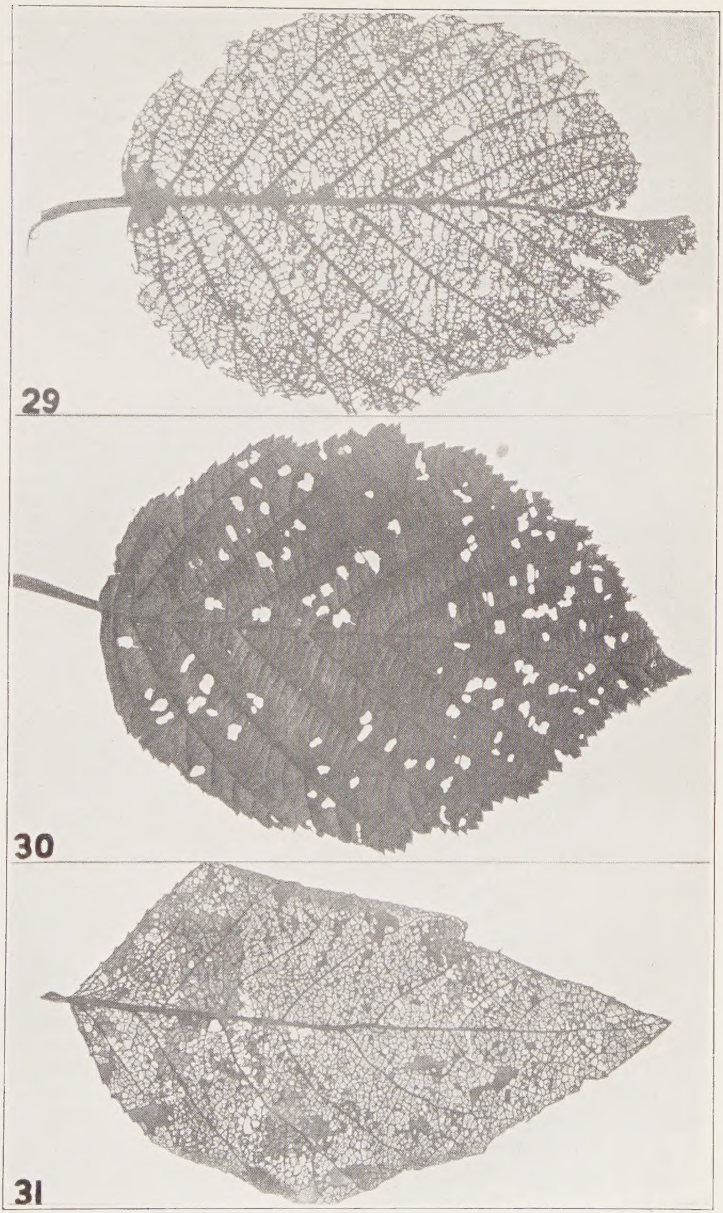

Altica bimarginata. Fig. 29: work of larva on alder; fig. 30: work of adult on alder; fig. 31: work of larva on balsam poplar.

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